

FINAL TECHNICAL REPORT
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Robert N. Miller

Numerical Modeling of Synoptic Scale Ocean Dynamics

Research continued on theory and practice of data assimilation. Results of a study of the application of optimal interpolation (OI), the data assimilation method most commonly used in numerical weather prediction, to a regional data set were published. In that study, hydrographic data from the California Current were assimilated into the Harvard quasigeostrophic open ocean model. Good results were obtained, but the outcome of the experiments were highly sensitive to boundary conditions.

A study of the application of advanced data assimilation methods to simple highly nonlinear systems which exhibit strongly nonlinear behavior such as bimodality and chaos was completed. Most data assimilation methods were derived under assumptions of linearity, and therefore could be expected to fail when applied to systems which exhibit multiple equilibria or chaos. Failure of the most commonly proposed methods was demonstrated. Modifications were derived to deal with nonlinearity and successfully tested.

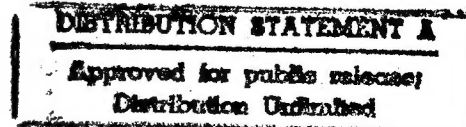
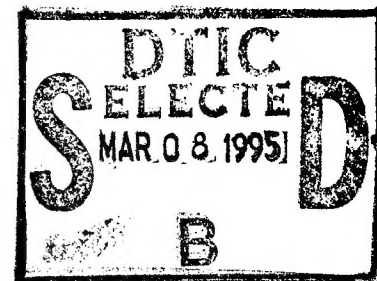
A finite element quasigeostrophic model of the Kuroshio near the coast of Japan was implemented and tested, and found to exhibit multiple stable equilibria in parameter ranges of physical interest. These multiple equilibria correspond to the observed formation and decay of the large meander inshore of the main current off the coast of Honshu. We plan to apply our newly-developed data assimilation methods for nonlinear systems to this model.

Theoretical results pertaining to application of adjoint data assimilation methods to regional and large-scale models were obtained. Appearance of high-wavenumber noise which had been noted in a number of published data assimilation studies was found to be the result of omission of necessary constraints in the original formulation of the methods. Application of adjoint methods to models with convective adjustment was found to result in nonunique solutions unless additional constraints were added to the variational formulation.

LIST OF PUBLICATIONS

- Rienecker, M. M. and R. N. Miller, Ocean Data Assimilation Using Optimal Interpolation with a Quasigeostrophic Model. *J. Geophys. Res.*, **96**, 15093-15103, 1991.
- Bennett, A. F. and R. N. Miller, Weighting Initial Conditions in Variational Assimilation Schemes. *Mon. Wea. Rev.*, **119**, 1098-1102, 1991.
- Miller, R. N., M. Ghil and F. Gauthiez, Advanced Data Assimilation in Strongly Nonlinear Dynamical Systems, *J. Atmos. Sci.*, **51**, 1037-1056, 1994.

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DATA QUALITY INSPECTED 3

Miller, R. N., E. D. Zaron and A. F. Bennett, Data Assimilation in Models with Convective Adjustment. *Mon. Wea. Rev.*, **122**, 2607-2613, 1994.

Miller, R. N. and M. Ghil, Data Assimilation in Strongly Nonlinear Current Systems. Int'l Symposium on Assimilation of Observations in Meteorology and Oceanography, Clermont-Ferrand, France, 9-13 July, 1990. World Meteorological Organization, 93-98, 1990.

Miller, R. N., Application of Optimal Data Assimilation Techniques in Oceanography. In: Proc. Summer Program in Environmental Studies. IMA volumes in Mathematics and its Applications. Institute for Mathematics and its Applications, Minneapolis, MN and Springer-Verlag. 1992.

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